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Are Production Decisions Decoupled under a Bond Scheme? Experimental Evidence

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Experimental economics procedures were used to investigate impacts of a proposed bond scheme on production decisions. As expected, production with subsidy payments tied to a support price was substantially higher than with no policy. A shift from the support price to equivalent annual or lump-sum payments not tied to price resulted in production at or near no-policy levels, providing empirical evidence to support the theoretical prediction that bond schemes would not result in production distortions. Potential extensions to the basic model used in this study also are presented.

For more than 20 years—since the Uruguay Round of global trade negotiations at least—agricultural policy discussions have focused on increasing market orientation in the agricultural sector. Reforms to "decouple" payments to farmers follow this interest by minimizing the distorting effects associated with tying production decisions to government subsidies. A new generation of policy options aimed at minimizing production and trade-distorting effects (such as counter-cyclical payments, private risk-management incentives, buyout bonds, and other income transfers) come with little or no experience on which to base an evaluation of economic impacts. Economic theory often provides a hypothesis that these "decoupled" programs are less distortionary than traditional price supports, but empirical evidence is limited. The objective of this research is to contribute to a

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basic understanding of the impacts of alternative agricultural subsidy programs on production decisions using experimental economics techniques.

Experimental economics is well suited where data for traditional analyses are not available. The laboratory can provide a controlled setting in which to investigate effects of proposed farm policies. The experimental markets described in this paper are intended to establish a basic model to understand the economic impacts of decoupled policy on commodity production decisions. Specifically, laboratory results are used to evaluate production decisions under a proposed bond scheme relative to a traditional deficiency payment program. Finally, potential extensions to the basic model are presented and discussed.

Experimental Procedures and Markets

Experimental sessions and aggregate supply and demand schedules follow standard procedures (Davis and Holt; Friedman and Sunder) and related previous research (Menkhaus et al.; Menkhaus, Phillips, and Bastian; Phillips, Menkhaus, and Krogmeier). Students recruited to participate in market experiments[1] produce "units" which are exchanged for "tokens" over a computer network. Units have no intrinsic value except for their redemption value. Tokens have a fixed exchange rate of one token equal to one cent. Earnings accumulate during a sequence of production periods and participants are paid their token equivalent in cash at the end of the experiment.

Given that our primary focus is on production responses to policy, a simplified market was designed in which six participants make production decisions under coupled and decoupled policy treatments. In this generalized market agents produce a homogeneous commodity with costs incurred for each unit produced. Each participant makes production decisions knowing their collective production will set a price that clears the market. Prices are determined by the experimenter, taken from an aggregate demand schedule of redemption values based on the total number of units produced in a production period.

Redemption values begin at 130 tokens per unit and decrease by 10 tokens for each of eight units. Sellers are given unit production costs that begin at 30 tokens per unit then incrementally by 10 to 100 tokens for the eighth unit. Each seller is allowed to produce and sell up to eight units in a production period. Individual and aggregate supply and demand schedules are step functions (Davis and Holt, pp. 9–14).

The cost of the units produced is assessed before they are sold. This advance production method of delivery is common in agriculture where a decision is made before planting determining the amount of crop traded in that season, absent other production risks. At the beginning of each experiment participants are given an initial balance of 700 tokens to offset the costs of producing units in early periods.

An experimental session begins with a standard presentation of instructions followed by one or more practice sessions, using different unit costs than the primary experiment. Each seller is given an identical table of unit costs with these costs used in each treatment. A production period corresponds to one planting season. At the beginning of each period, sellers make a production decision. Sellers produce up to eight units and sell units beginning with the lowest-cost units. Trading is done automatically. The sale price is the same for each unit of production for the period. Period earnings equal price times the number of units produced minus total unit costs associated with the number of units produced. Losses signal sellers to adjust production in subsequent "seasons" or production periods. Payouts to participants were between $67 and $92 for each session.

Policy Treatments and Expected Impacts on Production

Alternative policy treatments were presented in combined-policy scenarios consisting of two 20-period policy segments. Sellers were made aware of policy treatments via instructions prior to each segment. Participants did not know in advance when policy segments would change or the experiment end. Production periods 1 to 20 are referred to as policy segment *A*; periods 21 to 40 are referred to as segment *B*. Four policy treatments were investigated:

No Policy

A base treatment consists of a market with no policy intervention. In aggregate, the predicted equilibrium price is 80 tokens and quantity is between 31 and 36 units, given six sellers in the experiment.

Deficiency Payment

A deficiency-payment treatment is designed to mimic a traditional commodity program, providing sellers a subsidy tied to production through a guaranteed support price. A per-period subsidy paid to each seller is equal to the difference between a support price and the average market price times the number of units produced by the individual seller. A subsidy is paid only if the market price falls below the support price in that period. A support price of 90 tokens was determined using the predicted equilibrium price (80 tokens) plus a premium calculated using historical commodity support prices.[2] The predicted equilibrium quantity with the deficiency payment in place is between 37 and 42 units.

Bond Scheme

Two treatments follow a proposed bond scheme (Orden and Diaz-Bonilla; Swinbank and Tranter) in which an entitlement would be attached to an individual producer with no ties to current production, land use, or prices. Such a scheme would allow farmers who want to retire or diversify their investments to cash in future payments and receive a lump sum. Others might want to use annual returns to invest in the agricultural business or as household income. In a simple setting, theory suggests income transfers such as these should not have a direct impact on production decisions (Swinbank et al.). Payment alternatives for assessing the market impacts of a bond scheme are as follows.

Annually Paid Bond Subsidy

A periodic or "annual" payment of 50 tokens per period is added to each seller's earnings at the beginning of each of 20 production periods. The subsidy amount is calculated to equal the average amount per seller paid out under the deficiency-payment treatment with a support price of 90 tokens outlined above.

Lump-sum Bond Subsidy

A single lump-sum payment of 1,000 tokens is paid to each seller at the beginning of each 20-period policy segment. This payment is equal to the sum of the annual payment subsidy (or average deficiency payments) for 20 production periods. (A time element is not incorporated into the experimental design, so impacts between the annual and lump-sum payments related to time preference for money are not expected.)

Policy Scenarios

Base policy scenarios include 40 periods each of the no policy and deficiency payment treatments. Combined-policy scenarios are intended to mimic a policy shift from a traditional "coupled" payment program to an alternative program not tied to price. Combined-policy treatments consist of 20 periods of deficiency payments followed by 20 periods with an equivalent bond subsidy paid out periodically or in a lump sum.

Table 1 includes the number of replications conducted for each policy treatment. The data for analysis represent averages across these replications.

Table 1. Replications, convergence model results, and descriptive statistics for production by policy treatment

		Descriptive Statistics			Convergence Model Results	
Policy Treatment	***n*[1]**	**Production Period**	**Units Produced**	**Standard Deviation**	**Parameter Est. (Std. Error)**	**Est. Converg. Level[3]**
Policy segment *A*						
No policy	2	1–10	32.10	1.41		33.00[a] (Base)
		11–20	32.75	1.07	(0.24)	
Deficiency payment	8[2]	1–10	34.24	3.14	2.92	35.92[b]
		11–20	35.69	2.64	(0.25)	
Policy segment *B*						
No policy	2	21–30	32.85	0.81	−0.13	32.87[a]
		31–40	33.05	0.60	(0.28)	
Deficiency payment	2	21–30	37.10	1.71	1.60	37.40[c]
		31–40	37.55	1.05	(0.35)	
Annual bond payment	3	21–30	33.13	1.50	0.12	32.99[a]
		31–40	33.00	0.41	(0.23)	
Lump-sum bond payment	3	21–30	31.67	2.70	−0.93	31.94[d]
		31–40	31.73	2.39	(0.20)	

[1]Number of replications.
[2]Data used for the deficiency payment treatment in policy segment *A* are averaged over all combined policy treatment replications including a deficiency payment treatment in the first policy segment.
[3]Estimated convergence levels, adjusted for policy segment, are cumulative adjustments to the base by treatment.
[a. . .d]Same letter in superscript indicates no significant difference between the convergence levels in the respective equations; different letters indicate a significant difference between convergence levels, $\alpha = 0.05$.

Data Analysis

Data from experiment treatments were analyzed in three ways: through simple descriptive statistics, using a standard convergence model, and graphically. Analyses presented in this paper focus on units produced.

Descriptive statistics include mean production from the first and second half of each policy segment along with standard deviations. The standard deviations, combined with graphical analysis, provide evidence of experimental results trending toward a relatively stable level of production.

General impressions of the data from the descriptive statistics and graphical representations can be advanced by studying convergence levels via a statistical model. The convergence model provides a way to describe mean convergence levels over time and compare differences in these convergence levels across experimental treatments. The following general convergence model, a variant of which was developed by Ashenfelter et al. and Noussair, Plott, and Riezman, is estimated to describe the data and allow for statistical comparisons:

$$
\begin{aligned}
(1)\qquad Q_{it} = {} & B_0[(t-1)/t] + B_1(1/t) + B_2[((t-1)/t)S] + B_3[(1/t)S] \\
& + \sum_{j=1}^{i-1} \alpha_j D_j[(t-1)/t] + \sum_{j=1}^{i-1} \beta_j D_j(1/t) + \sum_{j=1}^{i-1} \gamma_j D_j[((t-1)/t)S] \\
& + \sum_{j=1}^{i-1} \delta_j D_j[(1/t)S] + u_{it}
\end{aligned}
$$

where Q_{it} equals the average total units produced across all replications for production period t $(1,\ldots,20)$ in cross section (treatment) i $(1,\ldots,6)$; B_0 and B_1 are the predicted asymptote and starting level of the dependent variable for the base category, respectively; S is a dummy variable representing policy segment; B_2 and B_3 are the predicted asymptote and starting level of the dependent variable for the base category adjusted for policy segment; D_j is a dummy variable separating the i treatments; α, β, γ, and δ are adjustments in asymptotes and starting levels for the ith treatment's relation to the base; and u_{it} is an error term.

The experimental data generated over several production periods and across treatments may be serially correlated and heteroscedastistic. These statistical issues, in the absence of a well-developed theory of the convergence process, present problems with an attempt to identify the patterns that may exist in the data. To account for this, the Parks method was used to estimate the model. The use of the Parks method allows us to take into account unique statistical problems resulting from panel data sets consisting of time-series observations on each of the several cross-sectional treatments. (See SAS for details of the Parks estimation method.)

Given our research objective of testing the potential impacts of policy on production decisions, we are primarily interested in differences between the estimated asymptotes of treatments or converged levels of production. The parameter estimate for the asymptote, which is the estimated convergence level for the base treatment presented in table 1, corresponds to the coefficient B_0 in the model above. Parameter estimates for adjusting the base asymptote for policy segment (B_2) and treatments (α and γ) are cumulative adjustments which lead to the estimated convergence levels of production over time reported in table 1. Additionally, tests of statistical differences between convergence levels of production are performed on asymptotic levels generated from parameters defined by the model. Differences are considered significant at α equals 0.05.

Results

Standard deviations of mean production levels dropped in the second half of each policy segment (table 1) indicating that variability in production decreases in later periods. The graphical analysis highlights this. Graphical and statistical analyses of production per period for treatments in combined-policy scenarios are reported below.

Base Policy Scenarios

A graphic representation of base policy scenarios is provided in figure 1. Production in the no-policy treatment converged to a level near 33 units with no statistical difference between policy segments (table 1). The deficiency payment policy resulted in a substantially higher level of production overall. Production under the deficiency payment treatment extended for a second policy segment trended slightly higher in later periods, with production in segment *B* converging at 37.40 (table 1). This result is within the predicted level of 37–42 units of production with a deficiency payment target price of 90 tokens according to aggregated supply and demand.

Figure 1. Production by treatment, base policy scenarios

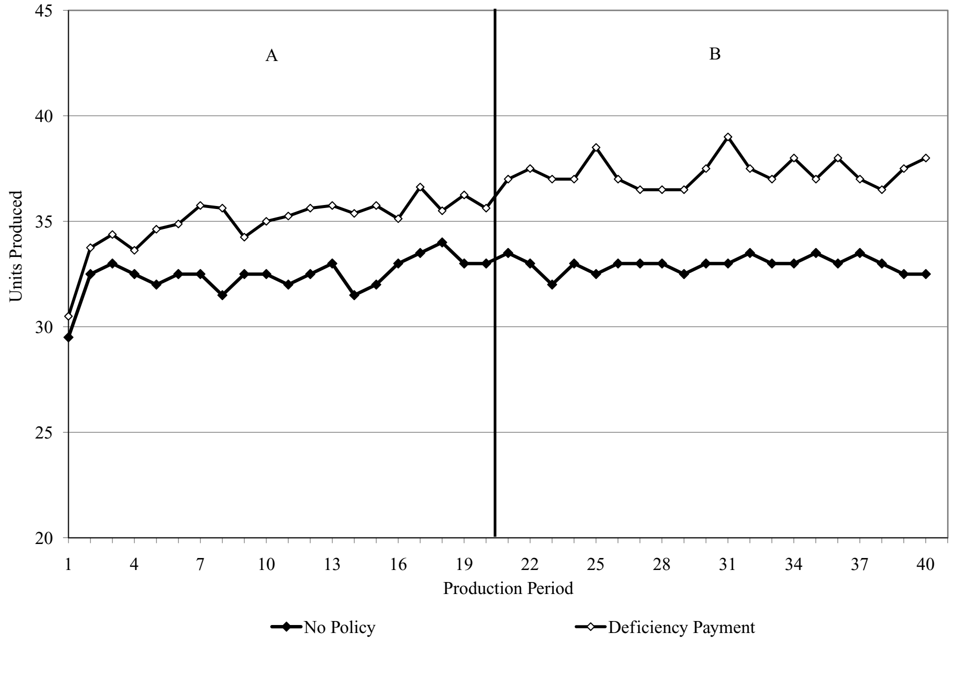
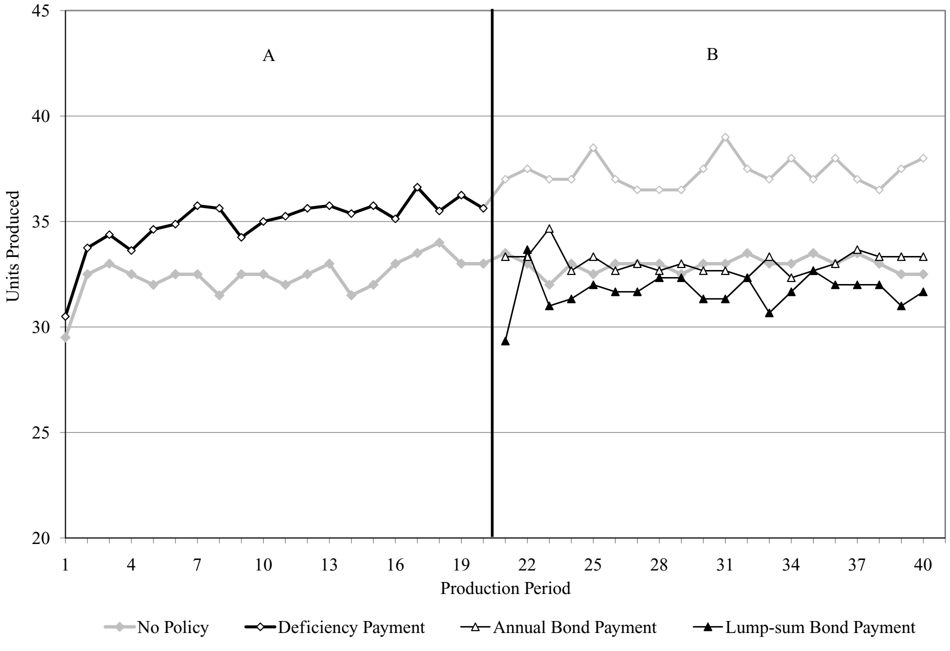


Figure 2. Production by treatment, combined policy scenarios



Combined Policy Scenarios

A graphic representation of policy combinations consisting of a shift from deficiency payments to annual or lump sum bond subsidies is presented in figure 2. (Base scenarios are indicated in gray for comparison.) In each combination a shift in production levels at the policy change in period 21 is apparent. Differences between the estimated convergence levels in segment *A* and *B* within each scenario are significant (table 1). Sellers accustomed to receiving deficiency payments produced and sold 36–37 units per period, however, when informed of a new subsidy equal to the payments they had been receiving but no longer tied to price, production immediately dropped. A change to annual payments of 50 tokens per period with no tie to price resulted in production converging at 32.99, a level not significantly different from production with no payments in segment *B*. When sellers were paid an equivalent lump-sum amount at the beginning of the second policy segment, production shifted to 31.94, a slight but statistically significant drop below the no-policy base (table 1). The no policy and bond scheme treatments have predicted convergence levels within the 31–36 unit level of production predicted by the aggregate supply and demand schedules.

Summary and Conclusions

As expected, production under the traditional deficiency-payment program treatment (with payments tied to price) is higher than with no policy in effect. In combined-policy scenarios where bond payments, which were not tied to price, were preceded by coupled deficiency payments production drops to at or near levels with no policy in place. These results support the theoretical prediction posed by Orden and Diaz-Bonilla, and Swinbank and Tranter that, in response to direct economic impacts at least, bond schemes will act as fully decoupled programs and will not introduce production distortions into the market.

Although bond scheme payments in this experiment did not appear to have a significant impact on the production decision, production impacts in actual agricultural markets could come from both institutional effects and indirect economic impacts. Alber and Blandford suggest several potential supply response mechanisms which they classify as static, uncertainty, and dynamic effects. Likewise, de Gorter, Just, and Kropp found sources of output distortion through cross-subsidization effects. Issues that would be worthwhile to investigate as potential extensions to the basic experiment reported here include:

- Increasing the verisimilitude of the trading institution to include buyers to further investigate market efficiencies of payments meant to boost producer income associated with bargaining behavior.
- Further investigation of indirect impacts on production due to changes or expected changes in income and wealth, expectations about future policy, and market behavior expectations.
- Results also serve to establish basic laboratory methodology for the comparison of policy treatments and other market impacts.

While laboratory experiments do not fully mimic real-world settings, they do provide the ability to predict basic agent behavior in a controlled environment and empirically test potential hypotheses regarding untried policies absent the cost of trial and error. The results from this study provide a baseline for additional analysis to further our understanding of new policies and their potential outcomes.

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Endnotes

[1]Experiment participants are university students recruited primarily from business and economics classes. Experimental studies have traditionally used students as subjects due to ready access, convenience in recruiting, low opportunity cost for students, relatively steep learning curves, and some lack of exposure to confounding external information (Friedman and Sunder).

[2]A premium was calculated using historical U.S. prices and commodity program support prices for wheat between 1974/1975 and 1995/1996 (United States Department of Agriculture):

$$\begin{aligned}\text{Premium} &= (\text{average 15-year target price})/(\text{average 15-year wheat price received})\\ &= (\$3.71/\text{Btu})/(\$3.26/\text{Btu}) = 1.138 \text{ or } 13.8\%.\end{aligned}$$

The predicted equilibrium price of 80 tokens increased by 13.8% yields the support price used in deficiency payment policy treatments of 90 tokens.

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